



Reusable Launch Vehicle Technology Program

Status Review

**RLV Executive Review
NASA Headquarters
May 24, 1995**

9:00AM	Introduction	Payton
9:10AM	Concept Definition & Optimization	Freeman
9:30AM	Technology Integration & Decision Criteria	Cook
9:45AM	Flight Demonstration Technology Programs X-33 Status / Plans X-34 Status / Plans DC-XA Status / Plans	Austin Kennedy Dumbacher
10:30AM	Core Technology Programs Status/Plans Reusable Cryogenic Tank Composite Structures TPS Avionics/VHM Advanced Propulsion	Dumbacher Camarda Cook Cook Monk
12:00 N	Adjourn	



Space Access & Technology

A large, bold, black 'X' logo, similar to the one in the top left, serves as a background for the central text box.

RLV Technology Program Background

**Gary Payton
May 24, 1995**



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Reusable Launch Vehicle (RLV) Program Description

Background: Access To Space Study Results

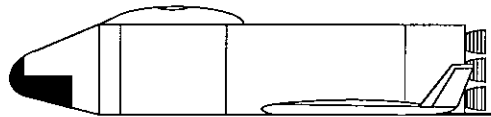
- Objectives Of Access to Space Study Were To Focus on Improving Reliability, Crew Safety And Reducing Operations Costs Of Future US Space Transportation.
- Results Of Access to Space Study
 - SSTO (Rocket) Vehicle Is A Feasible System That Can Achieve The Access To Space Objectives And Provide Major Life Cycle Cost And Performance Benefits To The Nation.
 - SSTO Design Is Integral With Cultural Changes In Operations And Management Strategies To Enable Significant Improvements Over Current Space Launch Infrastructure In Operations Costs And System Reliability.
 - **SSTO Technology Maturation Plan Features Enabling And Operations Oriented Technology Development Coupled With Ground Tests, Flight Experiments And X Vehicle Demonstration.**
 - **The Go Ahead To Proceed With Operational SSTO Launch System Development Is Keyed To Technology Maturation Results.**



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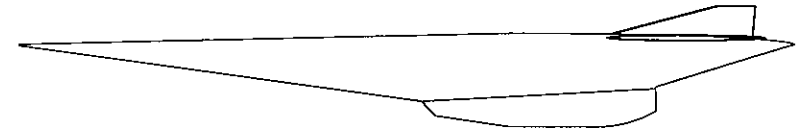
Access to Space Advanced Technology Team

Technology Requirements



SSTO Rocket

- Tri-Propellant Main Propulsion
- Alt: Advanced LOX/LH₂ Main Engine



SSTO Airbreather / Rocket

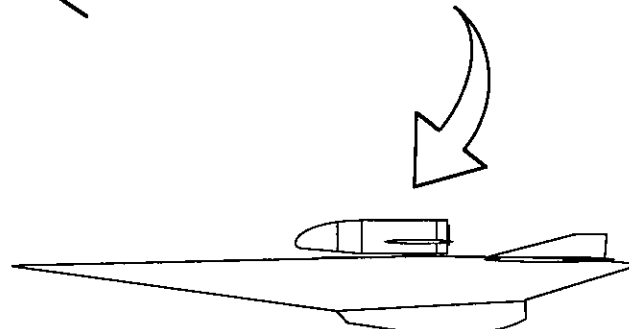
- Ram/Scramjet
- Actively Cooled TPS
- SLH₂

"Core"

Common Critical Technologies

DRIVEN BY OPERATIONS
NOT
PERFORMANCE

- Reusable Cryogenic Tankage
- Vehicle Health Management and Monitoring (VHM)
- Autonomous Flight Control
- Operations Enhancement Technologies
- Long Life, Low Maintenance Thermal Protection System



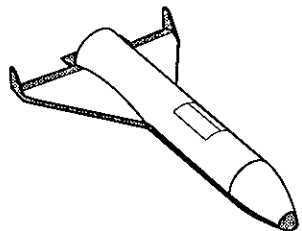
TSTO Airbreather / Rocket

- LH₂ Turbojet / Ramjet
- Expander Cycle Rocket Engine



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RLV Core Technology Program Applicability



Vertical Takeoff/Horizontal Land

Wing Body

- Tri-Propellant Main Propulsion
- Alt: Advanced LOX/LH₂ Main Engine



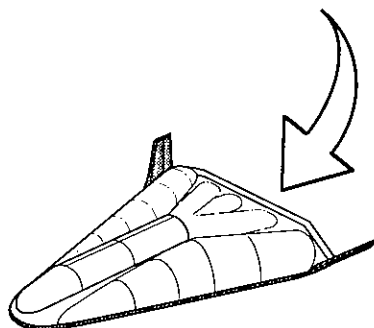
Vertical Takeoff/Vertical Land

- Rotation Maneuver
- Engine Restart

Common Critical Technologies

*OPERATIONS DRIVEN
TECHNOLOGIES*

- Reusable Cryogenic Tankage
- Graphite Composite Primary Structure
- Long Life, Low Maintenance Thermal Protection System
- Autonomous Vehicle Maintenance Requirements Identification
- Robust Main Propulsion
- Operations Enhancement Technologies



Vertical Takeoff/Horizontal Land

Lifting Body

- Linear Aerospike Rocket Engine



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Reusable Launch Vehicle Technology Demonstration Program

Core Technology Program

- Reusable Cryogenic Tank
- Graphite Composite Primary Structures
- Advanced Thermal Protection
- Advanced Propulsion
- Avionics / Operable Systems

Next Generation X Vehicles

DC-XA

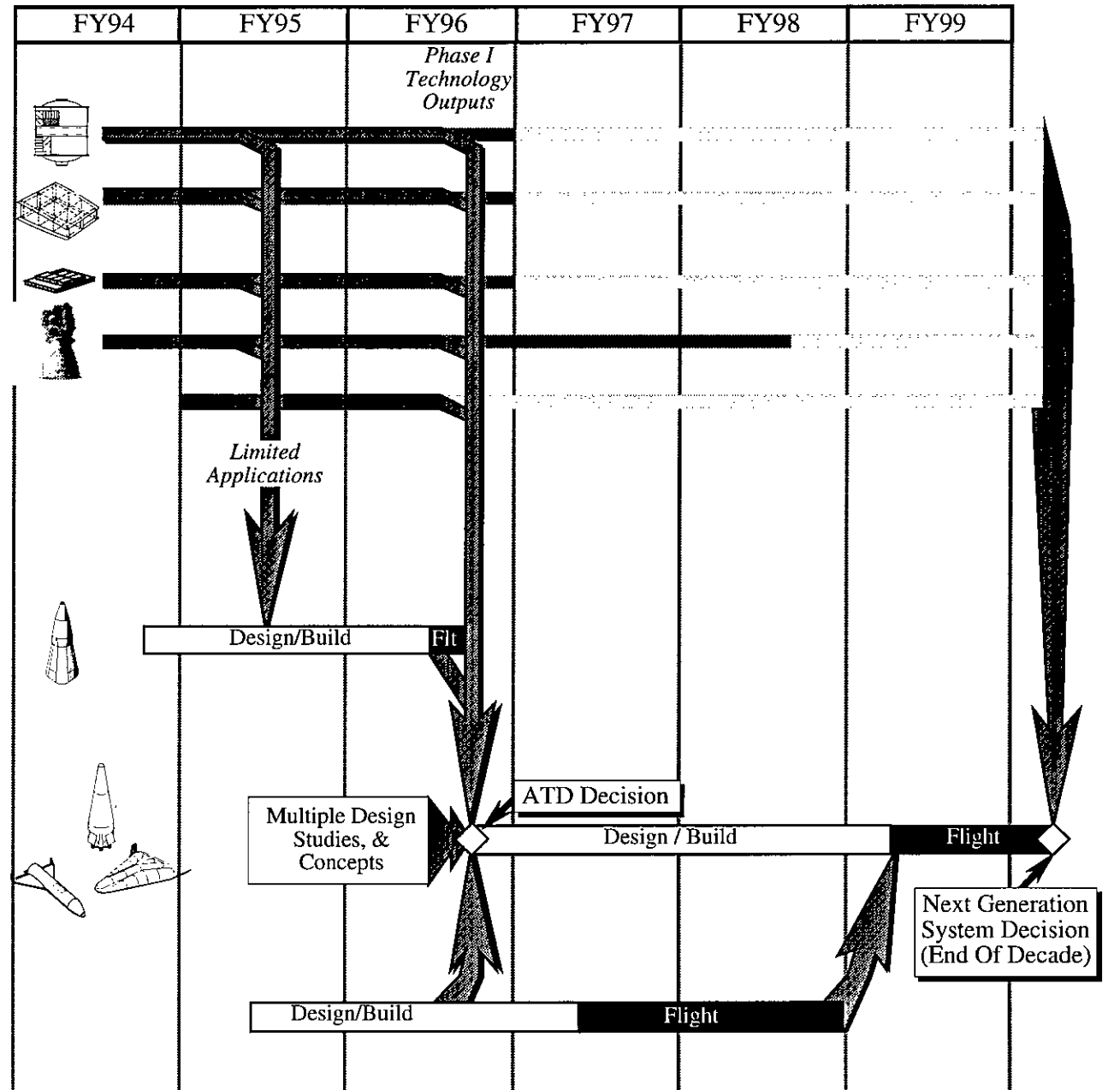
- Operations
- Advanced Technology

Advanced Technology Demonstrator: X-33

- Operations
- Vehicle Systems

Small Reusable Launch Vehicle Tech Demonstrator: X-34

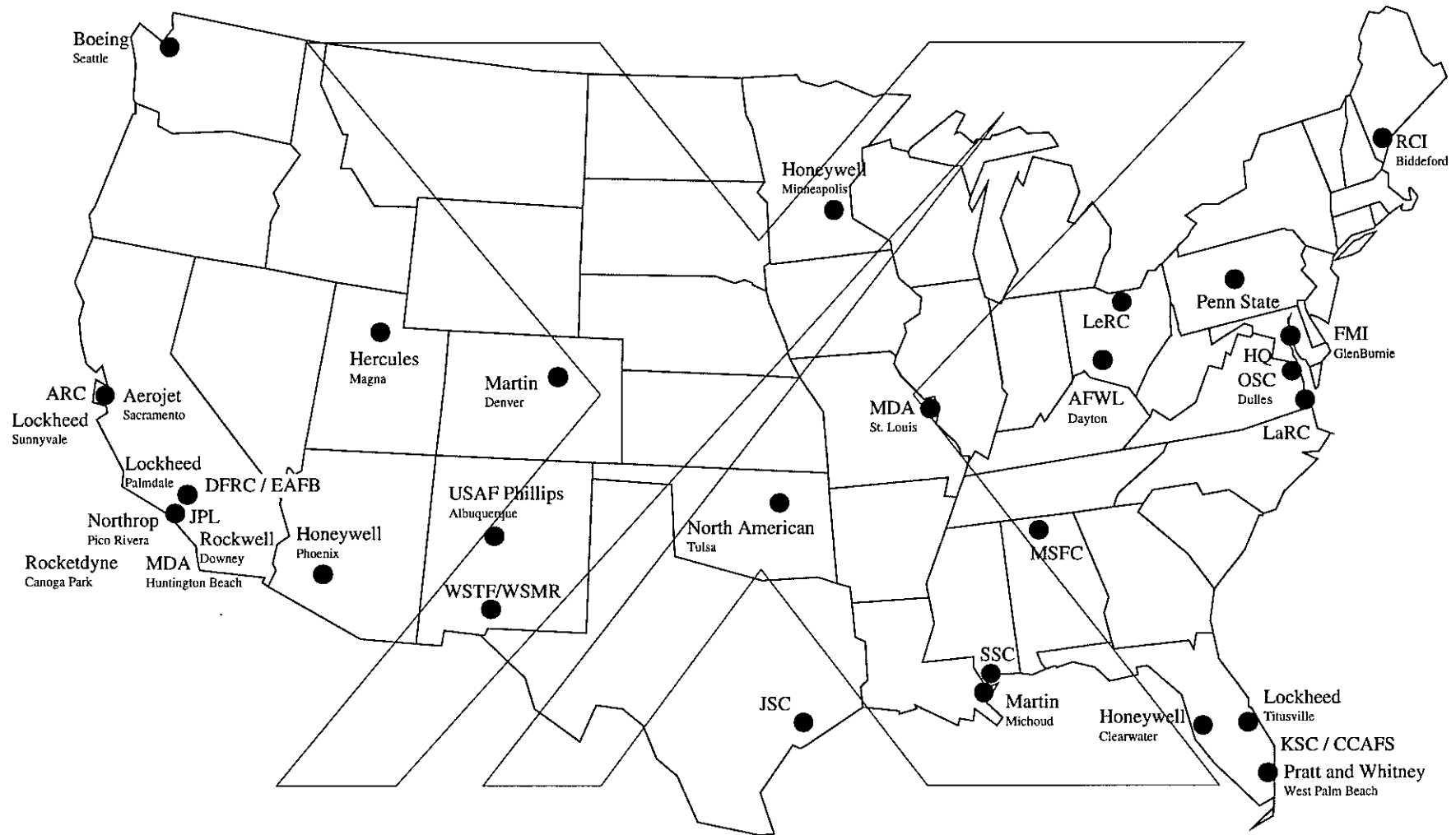
- Hypersonics
- Operations





Reusable Launch Vehicle Technology Program

Key Partners

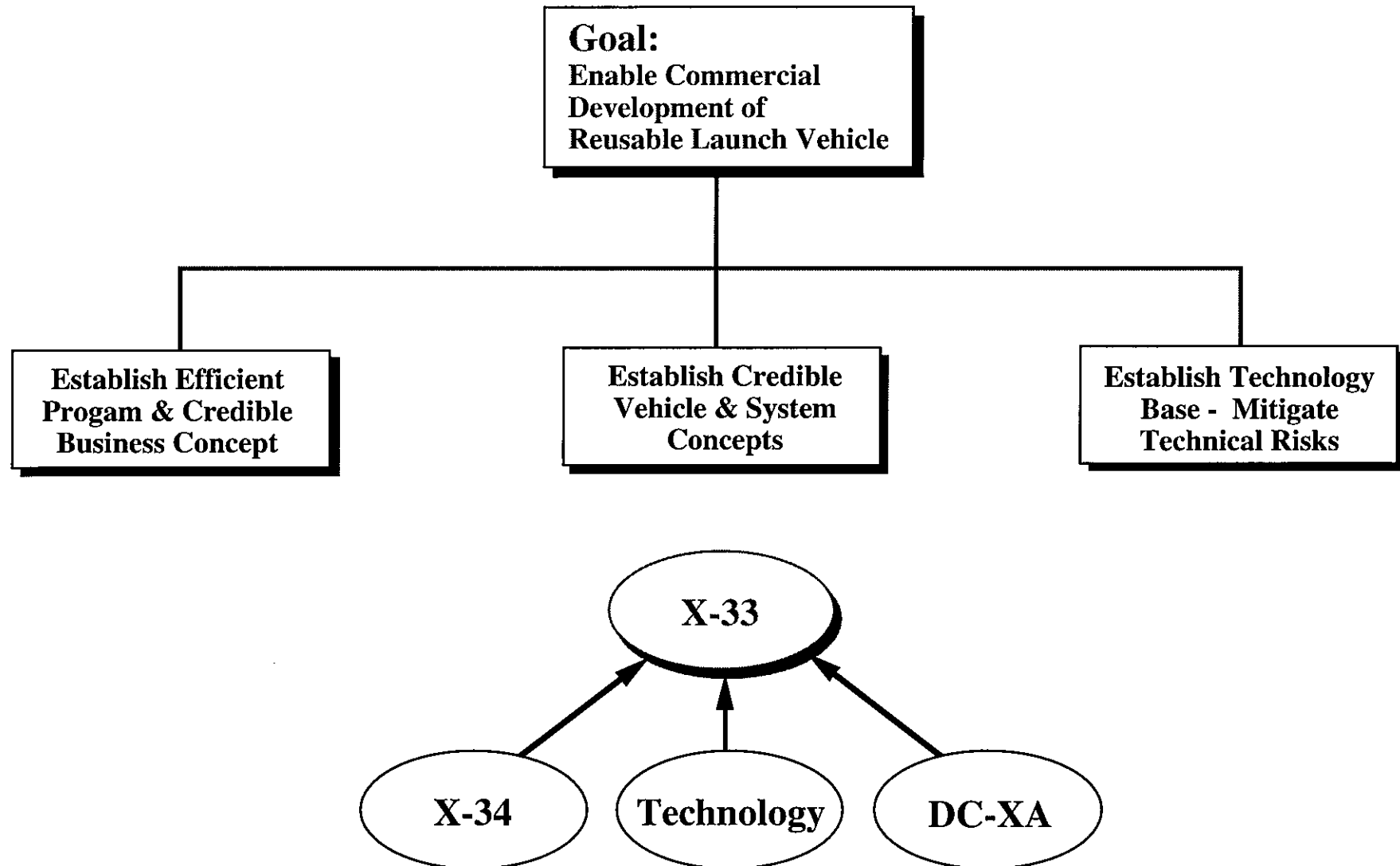




RLV Decision Criteria



RLV Contributions for Criteria





Phase II Criteria

- In Accordance with 11 Point Agreement Between Administrator and OMB (11/94)
- Criteria Developed Between NASA, OMB, OSTP for Measurement of Programmatic and Technical Progress
 - Required for Entrance Into Phase II (X-33 Development) and Phase III (RLV Development)
- Current Common RLV Requirements (To Be Updated)
 - 100 Mission Life Vehicle
 - Depot Maintenance \geq 20 Missions
- Notes:
 - Integrated System: Applicable Structure, TPS, Insulation, VHM, etc.
 - In-House: NASA Laboratory Complementary Tasks



Programmatic Phase II Criteria

- **Preliminary Business Plans for Next Generation System Development, Production and Operations (Phase II and III) will be Completed**
- **A Small and Efficient Project Office (20 total personnel) Will be Used with Streamlined Acquisition and Minimal Government Oversight**
- **Completed Initial Design Review and Two Non-Advocacy Reviews of the X-33**
- **X-33 Selection Will be Completed**



Technical Phase II Criteria

Reusable Cryogenic Tank System

Criteria

- **Al-Li**
 - One Integrated Tank System Mfg'd & In Test
 - Backup Coupon & Element Tests Complete
 - Scaled RLV Loads Where Applicable
 - **Gr-Composite**
 - One Integrated Tank System Mfg'd & In Test
 - Backup Coupon & Element Tests Complete
 - **Tank Material Selection Completed/Documented**
 - **Scalability to RLV Analysis Documented**
 - Technologies Can be demo'd by X-33
 - Correlations Between Test/Predictions to Validate Tools
- Current Est. Reqt's (To Be Updated)*
- **LH2 Weight Target: ≤ 0.5 lb/ft³**
 - **LOx Weight Target: ≤ 0.7 lb/ft³**

Activities

MDA DC-XA
MDA Ground
In-House
LADC

MDA DC-XA
RI
LADC

X-33

X-33



Technical Phase II Criteria

Primary Vehicle Structure

Criteria

Activities

- **Composite Intertank**
 - One Integrated System Mfg'd & In Test
 - Backup Coupon & Element Tests Complete

MDA DC-XA
MDA Ground (2)
In-House
RI
- **Composite Thrust Structure**

RI
- **Composite Wing/Aerosurface**

MDA/LaRC
RI
- **Material Selection Completed / Documented**

X-33
- **Scalability to RLV Analysis Documented**

X-33

 - Technologies Can be demo'd by X-33
 - Correlations Between Test/Predictions to Validate Tools

Current Est. Req't's (To Be Updated)

 - Airframe Weight Target: $\leq 4 \text{ lb/ft}^2$ (Not Inc. TPS/VHM, etc)



Technical Phase II Criteria

Thermal Protection Systems

<u>Criteria</u>	<u>Activities</u>
<ul style="list-style-type: none">• Ceramics<ul style="list-style-type: none">- One Test Article Mfg'd & In Test- Backup Element Tests Complete- Inc. Appropriate Attachment Mechanisms	MDA RI In-House
<ul style="list-style-type: none">• Metallics<ul style="list-style-type: none">- One Test Article Mfg'd & In Test- Backup Element Tests Complete- Inc. Appropriate Attachment Mechanisms	MDA/InHouse RI LADC
<ul style="list-style-type: none">• Material Selection Completed / Documented	X-33
<ul style="list-style-type: none">• Scalability to RLV Analysis Documented<ul style="list-style-type: none">- Technologies Can be demo'd by X-33- Correlations Between Test/Predictions to Validate Tools	X-33
<i>Current Est. Reqt's (To Be Updated)</i> <ul style="list-style-type: none">• Order of Magnitude Reduction in Maintenance Reqt's from STS	



Technical Phase II Criteria

Propulsion Systems

Criteria

- Update / Refocus of Technology Program by Aug, 1995
 - Propulsion Concept Selection
 - Supporting Component Technology Results Documented
-
- Scalability to RLV Analysis Documented
Current Est. Reqt's (To Be Updated)
 - 50% Reduction in Inspection Compared to Shuttle

Activities

X-33 et. al.

Completed

X-33 et. al.

Aerojet

P&W

Rocketdyne

Lockheed

MDA

Rockwell

Allied Signal

FMI

RCI

Penn State

X-33 et. al.



Phase II Criteria Summary

- Criteria Will be Updated as X-33 Studies & Technology Demonstrations Progress
- Performance Criteria (e.g., Weight Metrics) Must be Reviewed on System Level
 - Configuration Specific
- Criteria Intended as Program's Measure of Success
- Phase III Criteria Keyed Primarily Around Government and Business Investment Commitments
 - Based on Technical and Operational Demonstrations by X-33 / X-34



X-34 Small Reusable Launch Vehicle

Orbital
Sciences
Corporation



Rockwell

X-34 Primary Objective



- Demonstrate advanced technologies for larger reusable launch systems in two ways:
 - Incorporating advanced technologies into the basic X-34 design
 - Providing capability for technology test bed flights for additional demonstrations

X-34 Typical Trajectory

Orbital
Sciences
Corporation

OCS



Rockwell

